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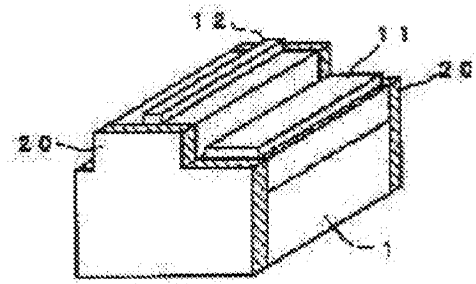
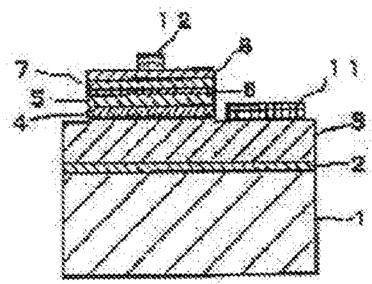
(54) NITRIDE SEMICONDUCTOR LASER ELEMENT

(57)Abstract:
PURPOSE: To form a suitable optical resonance surface turning to a reflecting mirror, by forming a dielectric multilayered film having a reflection factor corresponding to oscillation wavelength on the nitride semiconductor surface turning to the optical resonance surface.
CONSTITUTION: A double heterostructure is formed by laminating a buffer layer 2 composed of GaN, an N-type contact layer 3, an N-type clad layer 4, a second N-type clad layer 5, an undoped active layer 6, a P-type clad layer 7, and a P-type contact layer 8 on the [0001] face of a sapphire substrate 1. A stripe type positive electrode 12 is formed on the surface of the P-type contact layer 8, and a negative electrode 11 is formed on the surface of the N-type contact layer 3. The respective ten layers of SiO2 and TiO2 are alternately laminated over the nitride semiconductor (InxAlyGa1-x-y, 0≤x, 0≤y, x+y≤1) surface and the sapphire substrate to form a dielectric multilayered film 20. The dielectric multilayered films 20 are formed on the facing surfaces of the nitride semiconductor layer, reflect the light emitted from the active layer, and act as perfect optical resonance surfaces.





CLAIMS

[Claim(s)]
[Claim 1]a substrate top -- a nitride semiconductor ($In_X aluminum_Y Ga_{1-X-Y} N$.) A nitride semiconductor laser element which is a laser device which comes to laminate 0<=X, 0<=Y, and X+Y<=1, and is characterized by forming a dielectric multilayer at least in one side of an optical resonance side of the laser device.
[Claim 2]It is in a range whose luminous wavelengths of said laser device are 360 nm - 460 nm. The nitride semiconductor laser element according to claim 1 being the multilayer film which laminated at least two or more kinds of thin films chosen from a group which said dielectric multilayer furthermore formed in an optical resonance side becomes from SiO_2, TiO_2, and ZrO_2.

[Claim 3]The surface of [0001] sides of silicon on sapphire comes to laminate said nitride semiconductor, and the silicon on sapphire further said optical resonance side. [Equation 1]
$[1\bar{1}00]$

[Equation 2]
$[10\bar{1}0]$

[Equation 3]
$[01\bar{1}0]$

[Equation 4]
$[\bar{1}100]$

[Equation 5]
$[\bar{1}010]$

[Equation 6]
$[0\bar{1}10]$

The nitride semiconductor laser element according to claim 1 or 2 being the nitride semiconductor side broken by the plane direction of either of the fields.
[Claim 4]The nitride semiconductor laser element according to claim 1 or 2, wherein said optical resonance side is the end face of a nitride semiconductor etched almost vertically to a substrate.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application]This invention relates to the laser device which consists of nitride semiconductors $(In_X aluminum_Y Ga_{1-X-Y}N, 0<=X, 0<=Y, X+Y<=1)$.
[0002]
[Description of the Prior Art]The nitride semiconductor had a band gap to 1.95 eV - 6.0 eV, and since it was a transited [directly] type material, it was conventionally observed as a material of the semiconductor laser element to ultraviolet - red. blue LED of terrorism structure was put in practical use with the nitride semiconductor to double recently -- the next -- research of the blue laser element using the nitride semiconductor as a target came to be done actively.
[0003]It is necessary to form an optical resonance side in a semiconductor layer in a laser device. The semiconductor laser oscillated in the infrared region which consists of a compound semiconductor of the conventional GaAs system has cleavability on the character of a crystal, and the cleavage plane is made into the optical resonance side of a laser device.
[0004]On the other hand, the nitride semiconductor does not have the character top cleavability of a crystal called a hexagonal system. Therefore, when a laser device was produced with a nitride semiconductor, since an optical resonance side was not made by using a cleavage plane as a reflector, it did not result to laser oscillation.
[0005]
[Problem(s) to be Solved by the Invention]Ultraviolet - a green short wavelength semiconductor laser are

checked only with a ZnSe system semiconductor now, but the semiconductor laser has a life only several minutes at present. A possibility that the nitride semiconductor is realized to LED of terrorism structure as mentioned above to double, and laser can be realized at an early stage on the other hand as compared with ZnSe if this structure is used is high. Therefore, this invention is made in view of such a situation, and in realizing a laser device using a nitride semiconductor, there is a place made into the purpose in providing the laser device whose laser oscillation becomes possible by forming the suitable optical resonance side which serves as a reflector first.

[0006]

[Means for Solving the Problem]In realizing a nitride semiconductor laser element, by forming a dielectric multilayer in an optical resonance side of a nitride semiconductor layer where reflectance sufficient in the former was not obtained further, and raising reflectance to it, we find out newly that laser oscillation may happen to a nitride semiconductor layer, and came to accomplish this invention. namely, a nitride semiconductor laser element of this invention -- a substrate top -- a nitride semiconductor (In_Xaluminum$_Y$$Ga_{1-X-Y}N$.) It is a laser device which comes to laminate 0<=X, 0<=Y, and X+Y<=1, and a dielectric multilayer is formed at least in one side of an optical resonance side of the laser device.

[0007]The dielectric multilayer can change reflectance by laminating by turns an inorganic material in which reflectance differs mutually fundamentally, for example, laminating by turns by thickness (lambda / 4n (lambda: wavelength, n:refractive index)). A kind of each thin film of a dielectric multilayer, thickness, etc. can be designed by choosing those inorganic materials suitably according to wavelength of a laser device which it is going to oscillate. In the inorganic material, as a thin film material by the side of a high refractive index, for example, TiO_2, ZrO_2, HfO_2, and Sc_2O_3, Y_2O_3, MgO, aluminum$_2O_3$. At least one kind in Si_3N_4 and ThO_2 can be chosen. As a thin film material by the side of a low refractive index, SiO_2, ThF_4. Can choose at least one kind in LaF_3, MgF_2, LiF, NaF, and Na_3AlF_6, and A thin film material by the side of these high refractive indices, A dielectric multilayer can be formed by laminating several layers - tens of layers by a thickness of tens of A - several micrometers according to wavelength which combines suitably a thin film material by the side of a low refractive index, and is oscillated.

[0008]Next, the second of this invention is in a range whose luminous wavelengths of a laser device which comes to laminate a nitride semiconductor on a substrate are 360 nm - 460 nm. Said dielectric multilayer furthermore formed in an optical resonance side is characterized by being the multilayer film which laminated at least two or more kinds of thin films chosen from a group which consists of SiO_2, TiO_2, and ZrO_2. That is, when a laser device oscillated to 360 nm - 460 nm with a nitride semiconductor is realized, at least two or more kinds as which especially a dielectric multilayer formed in the optical resonance side was chosen from SiO_2, TiO_2, and ZrO_2 are most suitable. Because, in 360 nm - 460 nm, said three kinds of oxides have little optical absorption, are stuck very well with a nitride semiconductor, and do not separate. It is because it does not deteriorate even if long time irradiation of the light of said wavelength is furthermore carried out continuously, and it excels in a still more desirable thing dramatically to generation of heat of a laser device at heat resistance.

[0009]A dielectric multilayer can be formed using gaseous phase film production art, such as vacuum evaporation and weld slag. After a laser device is immersed in a solvent containing the above-mentioned compound in addition to this (dipping), it is also possible to repeat and form operation of drying. For example, when a dielectric multilayer which consists of SiO_2 and ZrO_2 is formed, Form SiO_2 and ZrO_2 with gaseous phase film production art, such as vacuum evaporation and weld slag, and also. It dries, after a laser device is immersed in a solvent of an organic metallic compound containing Si, It bakes by oxygen environment and is considered as an oxide, a laser device is immersed in a solvent of an organic metallic compound which contains Zr next, and after drying, a dielectric multilayer can be produced by repeating operation which is baked and is used as an oxide. However, it is better to use gaseous phase film production art in respect of thickness control preferably.

[0010]The nitride semiconductor structure laminated on a substrate should just be terrorism structure in double, for example, can be realized with structure which laminated a n type contact layer, a n type clad layer, an active layer, a p type clad layer, and a p type contact layer in order on a substrate. Sapphire (C side, A side, and R side are also included.), SiC (4H and 6H are included.), ZnO, GaAs, Si, etc. can be used for a substrate, and sapphire or SiC is used preferably. as a n type contact layer -- duality, such as GaN and AlGaN, -- what has a semiconductor layer of a mix crystal or a 3 yuan mix crystal good [crystallinity] is obtained. If especially GaN, an electrode material and desirable OMIKKU will be obtained. However, for considering it as a n type, donor impurities, such as Si, germanium, and S, are doped to a semiconductor layer. The following n type clad layer should just be a nitride semiconductor with a larger band gap than an active layer, for example, its AlGaN is

preferred. If the following active layer sets to non-doped n type InGaN, luminescence between bands about 635 nm - near 365 nm will be obtained. N type InGaN of crystallinity which made a mole ratio of indium below half to gallium preferably is good, and a life of a laser device is long. The following p type clad layer should just be the nitride semiconductor same with a n type clad layer with a larger band gap than an active layer, for example, its AlGaN is preferred. Acceptor impurity constituted from group II elements, such as Zn, Mg, and Cd, C (carbon), etc. by considering it as a p type is doped to a semiconductor layer. After a dope, annealing may be performed above 400 ** in order to use a still low resistance p type. the following p type contact layer -- a n type contact layer -- the same -- duality, such as GaN and AlGaN, -- what has a semiconductor layer of a mix crystal or a 3 yuan mix crystal good [crystallinity] is obtained. If especially GaN, an electrode material and desirable OMIKKU will be obtained. In structure of said laser device, it is still better also as a multilayer film which laminated three or more layers of active layers by tens of A thickness, i.e., multiple quantum well structure. although a mole ratio of group III elements of each class can be adjusted and 4 yuan can also be considered as a nitride semiconductor of a mix crystal (InAlGaN), since lattice matching of the interface of each nitride semiconductor layer is carried out further again -- general -- a 3 yuan mix crystal and duality -- a direction of a mix crystal is excellent in crystallinity. Especially, preferably, make thickness of an active layer thinner than 300 A, and. Between the active layer and n type clad layer and/or between said active layer and a p type clad layer, Since a laser device of distortion quantum well structure will be realized by distortion which comes from an interface of an active layer and a cladding layer by inserting an InGaN layer of a n type or a p type with a larger band gap than an active layer if it is made to transform an active layer elastically, laser oscillation becomes still easier.

[0011]Next, the third of this invention and the fourth are explained. Since a nitride semiconductor layer does not have cleavability as mentioned above, it is difficult to make a cleavage plane into an optical resonance side. However, it is vertical to **** and a state which is close to a cleavage plane, i.e., a substrates face, and it is possible by forming a field near a mirror plane to change into a state near an optical resonance side. As one of them, a laser device of the third this invention, The surface of [0001] sides (henceforth C side) of silicon on sapphire comes to laminate a nitride semiconductor, and further said optical resonance side, The silicon on sapphire is the nitride semiconductor side broken by a plane direction of several 1, several 2, several 3, several 4, several 5, or the 6th [several] pages (the 1st [several] page - the 6th page of a number are hereafter called M side collectively.), and a dielectric multilayer is formed in the resonance surface. That is, an optical resonance side which is close to a cleavage plane as much as possible is acquired by breaking a nitride semiconductor wafer laminated so that it might become the structure of a laser device on the surface of silicon on sapphire by a specific plane direction of a substrate. Since a nitride semiconductor side broken with sapphire is not a perfect cleavage plane, there is much optical loss. Then, in order to make the nitride semiconductor side into a perfect optical resonance side of optical loss which is not almost, a dielectric multilayer is formed further.

[0012]An unit cell figure showing a plane direction of a sapphire single crystal is shown in drawing 1. A nitride semiconductor which constitutes a laser device of this invention is laminated by C side of silicon on sapphire as shown in this unit cell figure, and orientation is carried out to C shaft orientations. It shall be contained in the range of this invention even if C side of silicon on sapphire is a C side which has an OFF angle in less than about **10 degrees from [0001] sides to say nothing of being thoroughly in agreement with [0001] sides. A laser device of the 3rd this invention makes a parting plane of a nitride semiconductor layer made when sapphire is broken by M side of an unit cell figure, i.e., the side of six[as shown in a slash part] -sided prisms, an optical resonance side.

[0013]A perspective view of 1 laser device concerning this invention is shown in drawing 2, and a sectional view at the time of cutting a laser device of drawing 2 in a direction vertical to a stripe electrode is shown in drawing 3. This laser device shows a mesa stripe type structure. The buffer layer 2 which comes from GaN on C side of the silicon on sapphire 1, the n type contact layer 3 which consists of Si-dope n type GaN, the n type clad layer 4 which consists of Si-dope n type AlGaN, the second n type clad layer 5 that consists of Si-dope n type InGaN, It has terrorism structure to double by which the active layer 6 which consists of non-doped InGaN, the p type clad layer 7 which consists of Mg-doped-p-type AlGaN, and the p type contact layer 8 which consists of Mg doped p type GaN were laminated. Furthermore, the negative electrode 11 of stripe shape is formed in the surface of the p type contact layer 8 as well as the positive electrode 12 of stripe shape, and the surface of the n type contact layer 3.

[0014]In order for this laser device to make fundamentally a nitride semiconductor side which was broken by M side of silicon on sapphire and which counters an optical resonance side and to make this field into a perfect optical resonance side further, This nitride semiconductor side and silicon on sapphire are covered, and the dielectric multilayer 20 which comes to laminate SiO_2 and ten layers of TiO_2 at a time by turns, respectively is formed. The dielectric multilayer 20 is formed in the surface of a nitride semiconductor layer which countered, respectively, it is reflected by this dielectric multilayer 20, and luminescence of an active layer serves as a

perfect optical resonance side. When sapphire is broken by M side, an optical resonance side of a nitride semiconductor is a hexagonal system. [Equation 7]
[11̄20]

It becomes a field in many cases.
[0015]A scriber or a dicer can be used as a means to break a wafer. When a scriber is used, the scribe of the silicon on sapphire of the field where the nitride semiconductor was laminated, and an opposite hand is carried out, but before carrying out a scribe, it is desirable to grind the silicon on sapphire in thickness of 100 micrometers or less still more preferably, and to make it thin 150 micrometers or less. When breaking a wafer from the scribe line formed so that it might be divided from M side by grinding a substrate to 150 micrometers or less, and making it thin, it becomes easy to be divided more straightly than a scribe line, and the broken nitride semiconductor layer side becomes close to an optical resonance side. On the other hand, in breaking by a dicer, after carrying out half cutting of the silicon-on-sapphire side by which the nitride semiconductor similarly is not laminated, an optical resonance side can be formed by pressing and breaking a wafer. When breaking a wafer by the half cutting by a dicer, and a scriber, by the thickness of silicon on sapphire being 150 micrometers or less as mentioned above, a nitride semiconductor layer breaks easily vertically to a substrate, and is in the tendency used as an optical resonance side.
[0016]Next, the end face of a nitride semiconductor into which a laser device of the fourth this invention was etched almost vertically to a substrate is an optical resonance side, and a dielectric multilayer is formed in this nitride semiconductor side etched vertically. That is, this laser device is also the same with the third laser device, and since only a resonance surface with much optical loss can be acquired only by etching. In order to acquire a perfect optical resonance side of optical loss which is not almost, a dielectric multilayer which reflects wavelength of an active layer in the surface of an etching surface of a nitride semiconductor further is formed, and an etching surface is made into a perfect optical resonance side.
[0017]Although a laser device in particular that makes an etched nitride semiconductor layer an optical resonance side is not illustrated, since a field which forms the dielectric multilayer 20 serves as the same figure, for example in drawing 2 even if it is the end face of the nitride semiconductor at the time of etching from the nitride semiconductor layer side, it omits. When forming an optical resonance side by etching, it is good that a substrate in particular with which a nitride semiconductor is laminated is not sapphire, either, and it cannot be overemphasized that materials, such as SiC and ZnO, may be sufficient as mentioned above.
[0018]After an optical resonance side of the fourth laser device forms a predetermined mask in the outermost surface of a laminated nitride semiconductor layer, it can be formed by etching. As an etching means, although there is a means of both dry etching and wet etching, for etching the end face of a nitride semiconductor vertically, dry etching is preferred. In dry etching, means, such as reactive ion etching, ion milling, ion beam assistant etching, and convergence ion beam etching, can be used.
[0019]If a concrete structure of a laser device is mentioned, as profit waveguide type stripe type laser, an electrode-stripes type, a mesa stripe type, a hetero isolation type, etc. can be mentioned. In addition to this, an embedding hetero type, a CSP type, a rib guide type, etc. can be mentioned as stripe type laser with a fixture waveguide mechanism. An electrode several to about 20 micrometers wide is usually formed in a laser device of such structures as a waveguide at the top layer (an example of the above-mentioned structure p type contact layer), and an oscillation is made to cause along with this stripe. It is formed in an optical resonance side for oscillating, for example on the nitride semiconductor layer surface of a direction vertical to this stripe. In addition to this, when laser of a surface-emitting type is produced, an optical resonance side is formed into a nitride semiconductor layer, but it is also possible to form a dielectric multilayer described above at least to one side of an optical resonance side of a surface emission-type laser in a laser device of this invention.
[0020]
[Function]When realizing a laser device using a semiconductor material without the cleavability of a nitride semiconductor, it is dramatically important to form the optical resonance side which serves as a reflector as stated first. Since the dielectric multilayer is formed in the optical resonance side of a nitride semiconductor layer in this invention, it acts as a reflector in which optical loss was excellent few by the dielectric multilayer. Although the dielectric multilayer mentioned above explains forming in both optical resonance sides, laser oscillation is possible even if it forms in either. For example, a dielectric multilayer can be formed in one of the two of an optical resonance side, and the reflector which already becomes one of the two from a metal thin film can also be formed.
[0021]When it is in the field whose oscillation wavelengths of the nitrides semiconductor laser are 360 nm - 460 nm, The laser device of a short wavelength region will not be realizable without at least two or more kinds of thin films chosen as the optical resonance side from the group which consists of SiO_2, TiO_2, and ZrO_2 forming the

laminated dielectric multilayer in the world. And, without sticking the material of SiO_2, TiO_2, and ZrO_2 very well with a nitride semiconductor, and separating, Since it does not deteriorate even if long time irradiation of the light of said short wavelength is carried out continuously, and it excels in the still more desirable thing dramatically to generation of heat of a laser device at heat resistance, in a room temperature, a prolonged continuous oscillation becomes possible.

[0022]In the laser device which laminated the nitride semiconductor to C side of sapphire, unlike the gallium nitride system compound semiconductor, the sapphire single crystal used as a substrate has dramatically good crystallinity, and as shown in drawing 1, it has an almost exact hexagonal system. On the other hand, also although a nitride semiconductor is called hexagonal system, it is not necessarily laminated on silicon on sapphire with the crystal form which was in agreement with the substrate. However, if the crystal system of sapphire is stable, by breaking a wafer by the direction of stable sapphire, it will become possible to make it easy to stabilize a nitride semiconductor and to divide, and it will change into a state as if it formed the cleavage plane by the gallium nitride system compound semiconductor. As the slash part of drawing 1 shows especially, since M side of sapphire has another [which certainly counters] M side, the optical resonance side which counters by breaking a wafer by those M sides is formed. If a dielectric multilayer is further formed in this resonance surface, since a perfect reflector will be made, laser oscillation of the nitride semiconductor is carried out easily.

[0023]By similarly, forming the end face vertical to a nitride semiconductor layer by etching, forming a dielectric multilayer in the end face, and carrying out the end face, since it is still insufficient as a reflector also as an optical resonance side, since light can be shut up thoroughly, a nitride semiconductor carries out laser oscillation easily.

[0024]

[Example]

[Example 1] Example 1 is described using drawing 2 and drawing 3. The buffer layer 2 which comes from GaN on the 350-micrometer-thick silicon on sapphire 1 First, 200 A, The n type clad layer 4 which consists of 5 micrometers and Si-dope n type aluminum0.3Ga0.7N the n type contact layer 3 which consists of Si-dope n type GaN 0.1 micrometer, The second n type clad layer 5 that consists of Si-dope n type In0.01Ga0.99N 500 A, The active layer 6 which consists of non-doped In0.08Ga0.92N 100 A, The wafer into which the p type contact layer 8 which consists of 0.1 micrometer and Mg doped p type GaN the p type clad layer 7 which consists of Mg-doped-p-type aluminum0.3Ga0.7N was grown up in order by 0.5 micrometer of thickness is prepared.

[0025]Next, after forming a mask in the surface of the p type contact layer 7 of this wafer in predetermined shape, using RIE (reactive ion etching), a nitride semiconductor layer is etched and the n type contact layer 3 is exposed. After exposing the n type contact layer 3, the negative electrode 11 which consists of Ti/aluminum is formed in the n type contact layer 3 by a width of 20 micrometers, and the positive electrode 12 which consists of nickel/Au is formed in the p type contact layer 7 by a width of 3 micrometers. Shape of an electrode is made into stripe shape as shown in drawing 2 and drawing 3.

[0026]Next, the field of the direction which does not form the nitride semiconductor layer of the silicon on sapphire 1 is ground to a thickness of 80 micrometers with a grinder. The scribe of the polished surface of silicon on sapphire is carried out with a scriber after polish. It is made for the scribe line of the direction of a scribe which intersects perpendicularly with a stripe electrode to correspond with M side of silicon on sapphire, and another scribe line is taken as a direction parallel to a stripe electrode. A wafer is pushed and broken with a roller after scribe line formation, and it is considered as a laser chip. It has shape as shown in drawing 2, the nitride semiconductor side which broke the wafer and was exposed is made into the optical resonance side, and this laser chip is 420 nm in luminous wavelength.

[0027]Next, after giving a mask to the whole electrode surface of a laser chip, the thin film which consists of SiO_2 is formed in the nitride semiconductor side exposed with the sputter device at 75 nm, Similarly the thin film which consists of ZrO_2 on it is formed at 48 nm, and the transparent dielectric multilayer 20 which laminated ten pairs of this pair is formed. Thus, the reflectivity curve of the formed dielectric multilayer is shown in drawing 4. The dielectric multilayer which consists of SiO_2 and ZrO_2 as shown in drawing 4 can reflect the wavelength 380 nm - near 450 nm 100%.

[0028]Thus, after installing the obtained laser device in the heat sink and carrying out the wire bond of each electrode, when laser oscillation was tried at the room temperature, laser oscillation with an oscillation wavelength of 420 nm was checked by threshold current density 1.5 kA/cm^2, and the continuous oscillation of 100 hours or more was shown.

[0029][Example 2] The wafer which set the presentation of the active layer of the laser device of Example 1 to

In0.15Ga0.95N is prepared. The luminous wavelength of this laser device is 460 nm. A laser chip is produced like Example 1 after grinding the back substrate and forming the electrode of stripe shape until it breaks a wafer by M side of sapphire.
[0030]Next, ten pairs of thin films which consist of 82 nm and TiO_2 the thin film which consists of SiO_2 are formed in the nitride semiconductor side exposed as well as Example 1 by 38-nm thickness. Although the reflectivity curve in particular of the thin film which consists of SiO_2 and TiO_2 does not illustrate, the reflectance of 460 nm shows about 100%.
[0031]Thus, the obtained laser device is installed in a heat sink like Example 1. After carrying out the wire bond of each electrode, when laser oscillation was tried at the room temperature, laser oscillation with an oscillation wavelength of 460 nm was checked by threshold current density 1.5 kA/cm^2, and, similarly the continuous oscillation of 100 hours or more was shown.
[0032][Example 3] After exposing the n type contact layer of the wafer of Example 1, a mask is removed and the mask (a line which becomes an electrode of the stripe shape formed behind, perpendicularity, and parallel has exposed this mask shape.) of predetermined shape is further formed in the surface of a p type contact layer. It etches until silicon on sapphire exposes a nitride semiconductor by $SiCl_4$ gas using the RIE etching device after mask formation.
[0033]the silicon on sapphire exposed by etching like the point after forming a positive electrode and the negative electrode like Example 1 after etching -- a scribe -- or dicing is carried out and it separates into a chip shape laser device. The rest forms a dielectric multilayer in the nitride semiconductor side which intersected perpendicularly with the electrode and was exposed like Example 1, and uses it as a laser device. Thus, as well as Example 1, laser oscillation was carried out at the room temperature, laser oscillation with an oscillation wavelength of 420 nm was checked by threshold current density 1.5 kA/cm^2, and the obtained laser device also showed the continuous oscillation of 100 hours or more.
[0034]
[Effect of the Invention]As explained above, since the laser device of this invention forms in the nitride semiconductor side used as an optical resonance side the dielectric multilayer which has the reflectance according to an oscillation wavelength, the laser oscillation of the optical resonance side as a reflector becomes possible by reflecting the light of an active layer about 100% mutually. In laser oscillation with a short wavelength of 360 nm - 460 nm, the laser oscillation of the short wavelength in a room temperature becomes possible by having formed the dielectric multilayer in a nitride semiconductor called SiO_2, TiO_2, and ZrO_2 with a suitable material. Thus, by having realized the laser device of the short wavelength region, as the light source for writing, and a light source of a compact disk, storage density improves by leaps and bounds, and the industrial utility value has it. [dramatically large]

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]The unit cell figure showing the plane direction of a sapphire single crystal.
[Drawing 2]The perspective view showing the shape of the laser device concerning one example of this invention.
[Drawing 3]The type section figure showing the structure of the laser device of drawing 2.
[Drawing 4]The figure showing the reflectivity curve of the dielectric multilayer formed in the optical resonance side of the 1 laser device of this invention.

[Description of Notations]
1 .... Silicon on sapphire
2 .... Buffer layer
3 .... N type contact layer
4 .... N type clad layer
5 .... The second n type clad layer
6 .... Active layer
7 .... P type clad layer
8 .... P type contact layer
11 ... Negative electrode
12 ... Positive electrode
20 ... Dielectric multilayer

[Translation done.]

* NOTICES *

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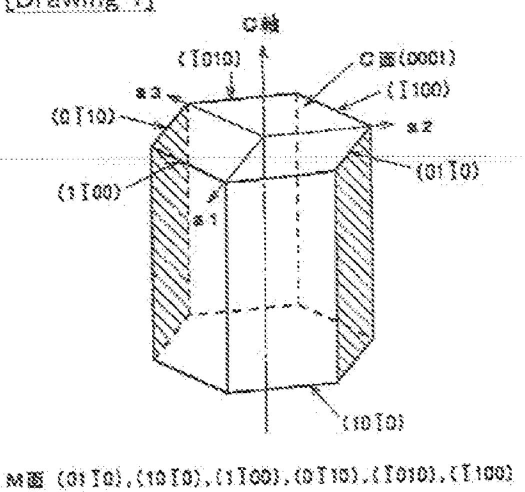
damages caused by the use of this translation.

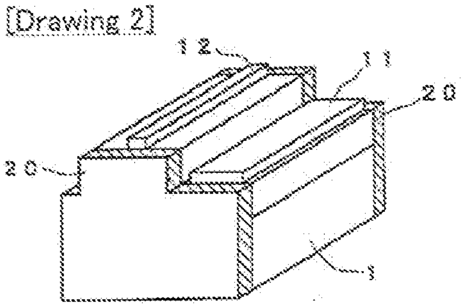
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

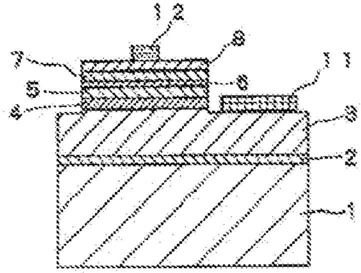
[Drawing 1]



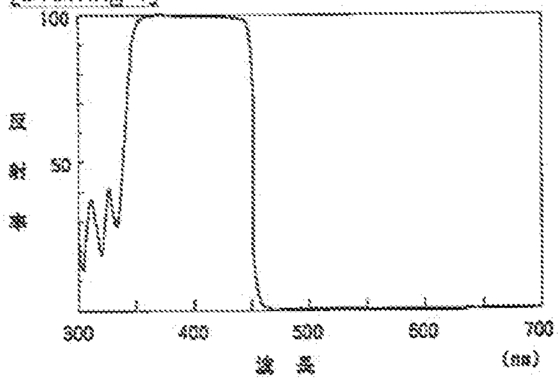
[Drawing 2]



[Drawing 3]



[Drawing 4]



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